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Short report

Bloodstream infections following different types of surgery in a Finnish tertiary care hospital, 2009–2014

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SUMMARY

The risk and outcome of bloodstream infections (BSIs) were evaluated following surgery. BSIs were identified in Helsinki University Hospital during 2009–2014 as part of the national surveillance. Of 711 BSIs identified, 51% were secondary and 49% primary. The rate was highest after cardiovascular surgery (8.7 per 1000 procedures) and lowest after gynaecologic (1.0 per 1000). Surgical site infection was the most frequent source of secondary BSIs (34%) and 45% of primary BSIs were central-line-associated. The 28-day case fatality ranged from zero in gynaecology/obstetrics to 21% in cardiovascular surgery. Besides BSIs related to surgical site infections, half of BSIs were primary, providing additional foci for prevention.

Introduction

Surgical patients frequently acquire healthcare-associated bloodstream infections (BSIs) [1–3]. Postoperative BSIs prolong hospital stay and increase cost, and most importantly may be related to severe outcome [4].

Most previous studies on postoperative BSIs have focused on a certain specific type of surgical procedure, especially on open heart surgery [4–6]. We located only one earlier study in which the risk of BSI after various types of operation had been compared [7]. Following that study, surgical techniques and postoperative treatment have changed widely.

Healthcare-associated BSI rates are usually reported by patient-days or when associated with device by central-line-days, usually in intensive care units (ICUs) [1,2]. However, postoperative BSIs, especially secondary, are related more to the surgical procedure itself than to the postoperative recovery period. To evaluate the risk and outcome of postoperative BSIs in various surgical procedures, we analysed the surveillance data of healthcare-associated BSIs from a tertiary care hospital located in the capital area of Finland during 2009–2014 and reported rates by number of surgical procedures.

Methods

Helsinki University Central Hospital (HUCH, 1983 hospital beds) provides tertiary care including all specialties of surgery for the capital city area of Finland, with a population of 1.2

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million. HUCH participated in the surveillance of healthcare-associated laboratory-confirmed BSIs as part of the Finnish Hospital Infection Program [1]. Surveillance was active, prospective, and hospital-wide, covering all patients admitted to departments offering acute care.

Infection control nurses regularly reviewed the laboratory database for positive blood culture results. The Centers for Disease Control and Prevention definition for healthcare-associated BSI was used, and only laboratory-confirmed BSIs were included in the study [8]. BSI was postoperative if the patient had been operated on during the same hospital stay or within 30 days of the BSI, if BSI was secondary to surgical site infection. 'Primary BSI' referred to bacteraemia or fungaemia for which there was no documented focal source and included infections that resulted from intravenous or arterial catheter infections. 'Secondary BSI' was defined as an infection that developed due to a documented infection with the same micro-organism at another body site.

All patients who underwent surgery in the operating room were recorded as having had surgery and the surgical procedure codes were reported. The procedures were classified by using Nordic Medico-Statistical Committee Classification of Surgical Procedures (NCSP) under the main chapters (A—H, J—N, P—Q), which arrange the surgical procedures into functional—anatomic body systems (Table I).

All BSIs that became evident during the ICU stay (at least 24 h) or within 48 h after discharge from the ICU were considered related to intensive care. The outcome at 2, 7, and 28 days from the date of the first positive blood culture was obtained from the national population registry by unique person identifiers allocated to all residents in Finland.

During 2009—2014, there were 3033 healthcare-associated BSI episodes in HUCH, of which 891 (29%) had preceding surgical procedure, i.e. were postoperative BSIs. Postoperative BSIs from the unit of paediatric surgery (180, 20%), mostly newborns, were excluded from the analysis due to the unique characteristics of this patient group.

The number of surgical procedures performed in an operation room was used as denominator when calculating the rates. The number of surgical procedures performed was obtained from the hospital database and included 456,209 surgical procedures during the study period. The 28,691 (6%) surgical procedures performed in the paediatric surgery unit were excluded.

Statistical analysis

The differences in non-normal distributions between two continuous variables were tested by the Mann—Whitney test. Data were analysed using IBM SPSS Statistics version 22.

Results

In all, 711 postoperative BSIs were identified during 2009—2014. The median age of the patients was 63 years (range: 0—93 years, with only eight patients aged <16 years undergoing surgery outside the paediatric surgery unit) and 57%

Table I

Data for bloodstream infections (BSIs) (primary, secondary, all) following various surgical procedures in Helsinki University Central Hospital, 2009—2014

Surgical procedure category (NOMESCO code)	No. of surgical procedures	All BSIs			Primary BSI	Secondary BSI	BSIs per 1000 procedures	28-day case fatality rate
		No.	Median age (years)	Male No. (%)	No. (%)	No. (%)	(95% CI)	No. (%)
Gastrointestinal (J)	56,447	165	65	88 (53)	104 (63)	61 (37)	2.9 (2.5—3.4)	20 (12)
Orthopaedic (N)	97,796	117	66	65 (56)	34 (29)	83 (71)	1.2 (1.0—1.4)	5 (4)
Cardiovascular (F)	8261	72	65	49 (68)	27 (37)	45 (63)	8.7 (6.7—10.7)	15 (21)
Urogenital (K)	17,430	63	67	53 (84)	16 (26)	47 (75)	3.6 (2.7—4.5)	5 (4)
Nervous system (A)	28,257	52	62	35 (67)	31 (60)	21 (40)	1.8 (1.3—2.3)	5 (10)
Obstetric procedures (M)	24,218	36	30	0	23 (64)	13 (36)	1.5 (1.0—2.0)	0
Peripheral vessels and lymphatic system (P)	14,640	32	68	23 (72)	13 (41)	19 (59)	2.2 (1.4—2.9)	6 (19)
Skin (Q)	19,619	28	52	16 (57)	15 (54)	13 (46)	1.4 (0.9—2.0)	5 (18)
Gynaecologic (L)	25,843	26	44	0	14 (54)	12 (46)	1.0 (0.6—1.4)	0
Minor surgical procedures (T)	4495	17	63	8 (47)	15 (88)	2 (12)	3.8 (2.0—5.6)	2 (12)
Chest wall, pleura, mediastinum, diaphragm, trachea, bronchus, and lung (G)	4590	12	53	9 (75)	5 (41)	7 (58)	2.6 (1.1—4.1)	2 (17)
Other [a]	48,330	19			10 (53)	9 (47)	0.4 (1.1—4.1)	2 (11)
Unclassified surgical procedures		72	61	48 (67)	40 (55)	32 (44)		7 (10)
Total	427,518	711	63	405 (57)	347 (49)	364 (51)	1.7	74 (10)

NOMESCO, Nordic Medico-Statistical Committee; CI, confidence interval.

[a] Surgical procedure categories with fewer than 10 BSIs were combined. These included teeth, jaws, mouth and pharynx, mammary gland, and endocrine system.

were males. The total number of surgical procedures performed during the six-year study period was 427,518 and the annual number of surgical procedures increased by 9%, from 67,545 to 73,563. The overall rate of postoperative BSIs was 1.7 per 1000 surgical procedures without any clear annual trend (range by year: 1.4–1.8).

The highest burden (number of cases) of postoperative BSIs was observed after gastrointestinal (165 episodes), orthopaedic (117) and cardiovascular (72) surgery, whereas the rates were highest in cardiovascular (8.7 per 1000 surgical procedures), urogenital (3.6) and gastrointestinal (2.9) surgery (Table I). The rates were lowest in gynaecologic (1.0) and orthopaedic surgery (1.2). The median age of patients (range: 20–68 years) and gender distribution (males: 0–84%) varied considerably between different surgical procedure categories.

Of the infections, 364 (51%) were secondary and 347 (49%) were primary. The distribution of secondary versus primary BSIs varied between surgical procedure categories (Table I).

Among the secondary BSIs, the most frequent sources of infection were surgical wound (125 episodes, 34%), urinary tract (97, 27%), gastrointestinal tract (54, 15%) and lung (22, 6%). Of the primary BSIs, 45% (155/347) were central-line-associated (CLABSI). Of primary BSIs, 38% (133/347) were related to intensive care (ICU); of these, 74% (98/133) were CLABSIs. In non-ICU wards, only 27% (57/214) of the primary BSIs were CLABSIs.

The causative agents of the BSIs varied by the origin of the infection. In CLABSIs ($N = 155$) the most frequently identified pathogens were coagulase-negative staphylococci (32, 21%), *Candida albicans* (27, 17%), and *Staphylococcus aureus* (26, 17%); in other primary BSIs ($N = 192$) *Escherichia coli* (27, 14%), *S. aureus* (22, 11%), and coagulase-negative staphylococci (22, 11%). In secondary BSIs ($N = 364$) most frequent were *S. aureus* (96, 26%), *E. coli* (72, 20%), and coagulase-negative staphylococci (37, 10%). One BSI was caused by meticillin-resistant *S. aureus* and 24 BSIs (3%) by extended-spectrum β-lactamase (ESBL)-producing Enterobacteriaceae. The proportion of the most frequent pathogens in secondary BSIs varied considerably between different surgical procedures (Figure 1). Staphylococci were especially frequent after cardiovascular (*S. aureus* 35%, coagulase-negative staphylococci 20%) and *S. aureus* after orthopaedic (73%) surgery, whereas *E. coli* and enterococci were frequent after gastrointestinal (26%, 20%) and urogenital (30%, 17%) surgery.

The two-day case fatality was 3% (21 episodes), the seven-day 4.5% (32) and the 28-day 10% (74). The patients who died within 28 days were older than those who survived (median age: 69 versus 63 years; $P < 0.001$). The 28-day case fatality did not differ between genders (11% in males versus 10% in females), neither between primary and secondary BSIs (9% versus 12%). Case fatality was highest in BSIs after cardiovascular surgery (within 28 days, 21%), especially in patients aged >65 years (Table I). None of the patients with BSIs following gynaecologic or obstetric surgery died.

Discussion

The present study, based on hospital-wide surveillance data, reports the risk of postoperative BSIs per operations performed. The data highlight prominent differences in the risk and in the source, causative agents, and the case fatality among various surgical procedure categories.

In our hospital nearly 30% of healthcare-associated BSIs occurred among patients with preceding surgery. The proportion was slightly smaller (26%) in a previous study from the same surveillance network including four Finnish hospitals during 1999–2000 [1]. A higher proportion (40%) has been reported from Estonia [2]. The differences in the proportions of the postoperative BSI in these studies may be partly related to the number and type of operations performed and to the comorbidities of the operated patients.

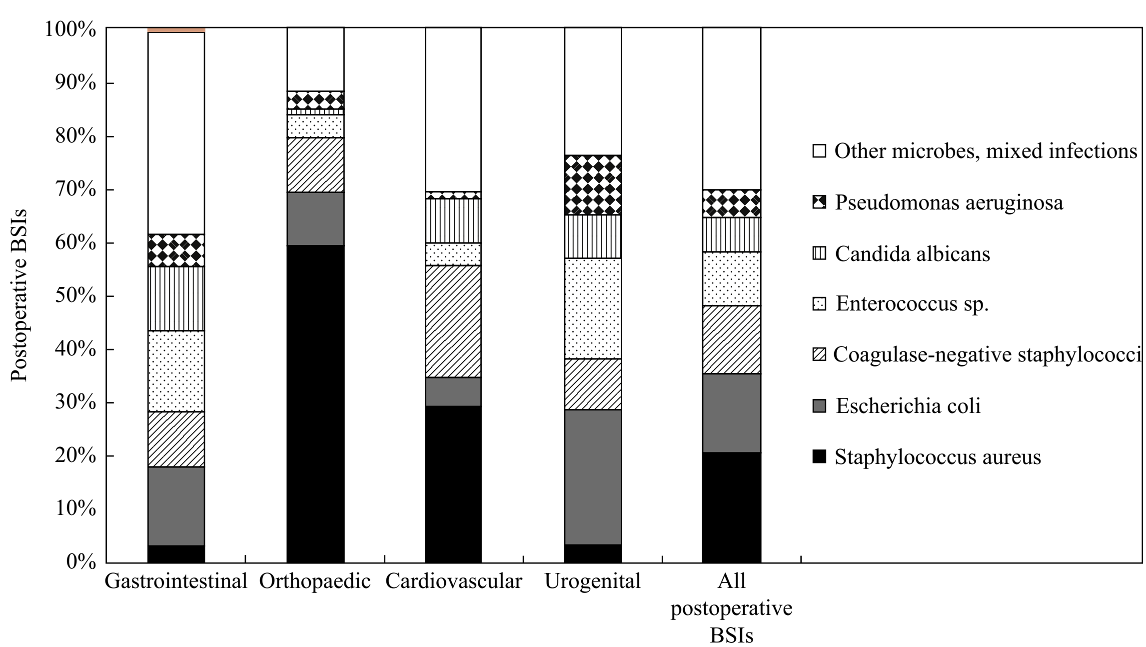

Figure 1. Causative agents of all postoperative bloodstream infections (BSIs) and in four surgical procedure categories with highest number of BSIs, Helsinki University Central Hospital, 2009–2014.

To the best of our knowledge, our study is the first to evaluate the risk of postoperative BSI and to relate this to the number of operations (1.7 per 1000 surgical procedures). The risk varied widely between surgical specialties (0.4–8.7 per 1000 procedures). Accordingly, the risk of secondary BSIs was highest in cardiac surgery in an older American study during 1986–1992 [7]. Comorbidities, duration of surgery, blood transfusions, duration of mechanical ventilation, complications irrelevant to the infection during ICU stay, and ICU readmission have been shown to increase the risk of infection after cardiac surgery [4–6].

In our study, around half of the postoperative BSIs were secondary. The proportion is higher than among all healthcare-associated BSIs in Finnish hospitals (39% in 2015, unpublished information from Finnish Hospital Infection Program by O. Lyytikäinen) and in Estonian hospitals (42%) [2]. The prevention of secondary BSIs should focus on means to reduce the number of surgical site infections, catheter-associated urinary tract infections, and postoperative pneumonias. The range of causative agents differed between surgical specialties. *S. aureus* and coagulase-negative staphylococci as a pathogen were prevalent after cardiovascular procedures, *S. aureus* after orthopaedic procedures, *E. coli* and enterococci after gastrointestinal and urogenital procedures.

About 22% (155/711) of all postoperative BSIs were central-line-associated and the majority of these (64%) were related to intensive care, underlying the importance of implementation of specific guidelines and bundles in order to prevent CLABSI in these units. In a one-day European prevalence study of patients with preceding major heart surgery in ICUs, 2.8% of the patients had CLABSI [9].

Of the postoperative BSIs, 27% (192/711) were primary BSIs in patients without central lines. These infections occurred mostly (in 82%) in non-ICU wards. A proportion of these may have been misclassified, since central line data may be more often incomplete in non-ICU wards. However, these primary BSIs may also have some unique risk factors, since the most frequent causative agents in CLABSIs were coagulase-negative staphylococci, whereas in those without central line documentation *E. coli* were most frequent. Thus, some of these BSIs may be unidentified surgical site infections or they may be related to urinary tract or peripheral catheters.

The case fatality in postoperative BSIs within 28 days was 10%, which is lower than the case fatality of all healthcare-associated BSIs in previous studies (16–40%) [1–3]. In fact, preceding surgery was a protective factor for death in a multivariate analysis of Finnish patients with and without healthcare-associated infections [10]. This may partly be related to preoperative assessment of potential benefits and risks of surgery. In our study, the case fatality was higher in elderly patients. It also varied considerably among different surgical specialties (0–36% within 28 days), being highest in patients with cardiovascular surgery (31%).

This study has some limitations. First, we did not have information on the type and severity of the patients' underlying diseases, which certainly partly explain the observed differences in the risk and case fatality of BSIs after different surgical procedures. Second, we did not have information on the number of central-line-days, which is the appropriate denominator to calculate CLABSI rates.

The strength of the study was that we performed a hospital-wide surveillance and reported the rate per surgical procedures performed. Another option would be to report postoperative BSI rate per patient-days. However, the risk of postoperative BSI is not evenly distributed between the patient-days. It is highest during the immediate postoperative period, often in ICU, and lower during non-ICU ward stay. It is difficult to study the temporal trends by using patient-days, because despite the increasing number of surgical procedures in HUCH (9% during the study period), the surgical patient-days have not increased (range by year: 127,595–150,955; 131,414 for the most recent year; gynaecologic and obstetric patient-days not included). This is likely due to the active measures performed to shorten the postoperative stay, such as admitting patients to the hospital not earlier than the day of surgery.

Both the rate (1.0–8.7 per 1000 procedures) and case fatality (0–21%) of postoperative BSI varied considerably by the type of surgical procedure. Both were highest after cardiovascular procedures and lowest after orthopaedic, gynaecologic, and obstetric procedures. These findings may also be related to differences in underlying risk factors of patients. Besides BSIs related to surgical site infections, a remarkable proportion of postoperative BSIs were associated with central lines, providing an additional focus for preventive efforts. The origin of primary BSIs not associated with central lines needs further investigation. The spectrum of causative agents differed by types of procedure, which should be considered when choosing empiric antimicrobial therapy for postoperative patients.

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Conflict of interest statement

None declared.

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